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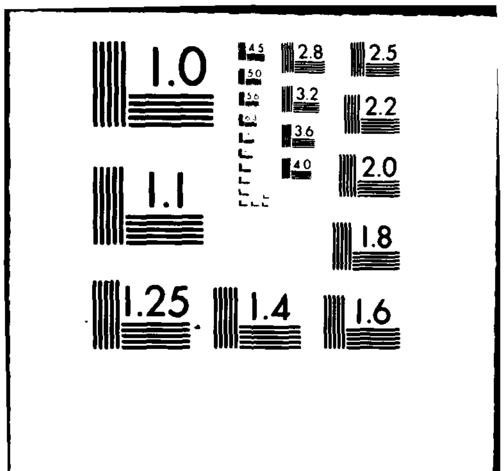

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CLIMATIC MAPS OF THE SEA SURFACE-AIR DIFFERENCE IN VAPOUR PRESSURE AND IN POTENTIAL TEMPERATURE OVER THE EASTERN INDIAN OCEAN (U)

BY

A. HIRST

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(6) Climatic Maps of the Sea Surface-Air Difference in Vapour Pressure and in Potential Temperature over the Eastern Indian Ocean. ~~(U)~~

by

(10) A. HIRST

ABSTRACT

Maps are presented in this report showing, 1. the mean difference between the vapour pressure at the sea surface and at a height at 10 m, and 2. the mean difference between the potential temperature at the ocean surface and at a height of 10 m, over the ocean surface from 5°S to 50°S and from 100°E to 140°E, for the months of February, May, August and November. The maps are derived from maps of relevant variables shown in the World Ocean Atlas (1976). The sizes of errors in the maps presented here are discussed. The largest errors arise from errors in the W.O.A. maps. (U)

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Maps are presented in this report showing, (1) the mean difference between the vapour pressure at the sea surface and at a height at 10 m, and 2) the mean difference between the potential temperature at the ocean surface and at a height of 10 m, over the ocean surface from 5°S to 50°S and from 100°E to 140°E, for the months of February, May, August and November. The maps are derived from maps of relevant variables shown in the World Ocean Atlas (1976). The sizes of errors in the maps presented here are discussed. The largest errors arise from errors in the W.O.A. maps. (U).

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INTRODUCTION

1. Knowledge of the mean difference between the vapour pressure at the sea surface e_o, and the vapour pressure at a height of 10 m, e_{10}, is useful in the climatic study of some atmospheric phenomena. In particular, it can be shown that the thickness of the surface radar duct, h_d, in near neutral conditions is approximated by the expression

$$h_d = \frac{72\ C_E}{\sqrt{C_D}} \overline{(e_o - e_{10})} \qquad \text{Eqn (1)}$$

where C_D is the drage coefficient of the ocean surface, and

C_E is the aerodynamic water vapour transfer coefficient (see Jones and Stewart, 1977). In near neutral conditions, C_D has been found to be approximately constant when the wind speed is less than 12 ms^{-1}(Antonia and others, 1978; Smith 1970). If C_E is assumed to behave similarly, then the mean duct thickness, $\overline{h_d}$, is proportional to the mean vapour pressure difference,

$$\text{i.e.} \quad \overline{h_d} = \frac{72\ C_E}{\sqrt{C_D}} \overline{(e_o - e_{10})} \qquad \text{Eqn (2)}$$

in a region where the atmosphere is mostly neutral and the windspeed usually less than 12 ms^{-1}. In an unstable atmosphere, the surface radar duct thickness is over-estimated by equations 1 or 2 (Jones and Stewart, 1977).

2. Maps have been prepared showing $\overline{e_o - e_{10}}$ over the ocean surface from 5^oS to 50^oS and from 100^oE to 140^oE, for the months of February, May, August and November. Maps showing the mean difference between the potential temperature at the ocean surface, θ_o, and at a height of 10 m, θ_{10}, have been prepared for the same region and the same months, primarily to indicate the expected stability above the ocean surface, and hence to applicability of Equation 2. However, instability will arise if $(e_o - e_{10})$ is large, even if $(\theta_o - \theta_{10})$ is small.

THE DATA SOURCE

3. Maps of mean sea surface temperature (SST), air vapour pressure and air temperature for the relevant region and the relevant months were obtained from the World Ocean Atlas, Vol. I: Pacific Ocean (1976). This atlas was used because it was the most recently published atlas available which contained monthly maps of the three relevant variables. The SST maps are based on oceanographic expedition data from 1925 to 1968, and on the data contained in ships' meteorological radio messages from 1950 to 1967. The SST isohyets are at 1^{o}C intervals. Maps of the air vapour pressures and air temperature "at the surface of the ocean" are given in the atlas. These maps are based on merchant ship and meteorological expeditions observations for the period 1890 - 1965. The air temperature isotherms are at 2^{o}C intervals and the vapour pressure isotherms are at 2 mb intervals. In order to find the values at the ocean surface, the data would have been corrected to sea level from the bridge height (usually 7 to 15 m) using adiabatic correction, i.e. the air temperatures have been corrected to potential temperatures. Thus the maps show the average vapour pressure and potential temperature at approximately 10 m in height.

METHOD

Preparation of the $e_o - e_{10}$ Maps

4. The air at the sea surface is assumed to be saturated and at the temperature of the sea surface. Thus the mean SST map can be readily transformed into a $\overline{e_o}$ map. For each month, the latitudes at which the SST isotherm crossed selected lines of longitude (100^{o}E, 105^{o}E, 110^{o}E etc) were recorded to a precision of 0.1^{o} . $\overline{e_{10}}$ was found at each point, usually by linear interpolation between the $\overline{e_{10}}$ isohyets on either side. Cubic interpolation was used when $\partial^2\overline{e_{10}}/\partial^2$ (latitude) was sufficiently great. These values of $\overline{e_{10}}$ were subtracted from the corresponding $\overline{e_o}$ values, to give the value of $\overline{e_o - e_{10}}$ at each point. The $\overline{e_o - e_{10}}$ isolines were positioned using linear interpolation between adjacent points.

Preparation of the $\overline{\theta_o - \theta_{10}}$ Maps

5. As both $\overline{\theta_o}$ and $\overline{\theta_{10}}$ maps have the same units (^oC) a much simpler method was used in preparing the $\overline{\theta_o} - \overline{\theta_{10}}$. Odd number isotherms were firstly generated on the $\overline{\theta_{10}}$ map by linear interpolation between the existing even number isotherms. Then the maps were superimposed and the positions at which the isotherms crossed outlined the $\overline{\theta_o} - \overline{\theta_{10}}$ isolines.

ERRORS

Reliability of the World Ocean Atlas

6. No indication of the area density of the data that were used to prepare the relevant maps is given in the World Ocean Atlas. Away from the main shipping routes, e.g. south of 40^oS, the data are probably very sparse. Further accuracy may have been lose because of the smoothing results from the use of $5^o \times 5^o$ averaging squares. Just before this report was completed, the World Ocean Atlas, Vol. 2: Atlantic and Indian Oceans (1977) became available. Additional data from several countries, especially the USA were used in preparing the maps at the Eastern Indian Ocean. Maps of the relevant variables were compared, and the SST in the 1976 Atlas was between 1^oC lower and 2^oC higher than in the 1977 Atlas (see Hirst, 1980), while $\overline{e_{10}}$ was between 0 and 2 mb higher, and $\overline{\theta_{10}}$ was between 1^oC lower and 1^oC higher. If these differences are used as estimates for the errors the 1976 Atlas values of $\overline{\theta_o}$, $\overline{e_{10}}$ and $\overline{\theta_{10}}$ from the true means, then the errors in the plotted $\overline{e_o - e_{10}}$ values will generally be smaller than ± 2 mb, while the errors in the plotted $\overline{\theta_o - \theta_{10}}$ values will generally be smaller than $\pm 2^oC$.

Additional Sources of Error

7. There are three additional sources of error;

a. The errors in reading the logitudes at $\overline{\theta}/\overline{e_o}$ isolines are estimated to cause errors of up to $\pm 0.2^oC$ or ± 0.2 mb respectively.

b. The errors in reading the longitudes at $\overline{\theta_{10}}$ and $\overline{e_{10}}$ isolines are estimated to cause errors of up to $\pm 0.2^oC$ or ± 0.2 mb respectively.

c. Interpolation is estimated to cause errors of up to ± 0.2 mb or $\pm 0.2^oC$ so the map reading and inter-

polation errors in $\overline{e_o - e_{10}}$ and $\overline{\theta_o - \theta_{10}}$ are estimated to be no greater than ± 0.2°C and ± 0.2mb. This error is much smaller than the estimated errors in the original Pacific Ocean maps.

PRESENTATION OF MAPS

8. The maps for each month are presented in the following order:

a. Mean Sea Surface Temperature (θ_o), with the corresponding saturated vapour pressure in brackets (from W.O. Atlas, 1976).

b. Mean Air Vapour Pressure ($\overline{e_{10}}$) (from W.O. Atlas, 1976).

c. Mean Air Temperature ($\overline{\theta_{10}}$) (from W.O. Atlas, 1976).

d. $\overline{e_o - e_{10}}$

e. $\overline{\theta_o - \theta_{10}}$

The	February	maps	are	labelled	1a to e
"	May	"	"	"	2a to e
"	August	"	"	"	3a to e
"	November	"	"	"	4a to e

DISCUSSION

General Trends in $\overline{e_o - e_{10}}$ and $\overline{\theta_o - \theta_{10}}$

9. In all four months, $\overline{e_o - e_{10}}$ tends to decrease towards the south, this trend being especially consistent south of 30°S. $\overline{e_o - e_{10}}$ varies between 7 and 10 mb at 15°S, between 4 and 7 mb at 35°S, and between 0 and 2 mb at 50°S. Most other variations in $\overline{e_o - e_{10}}$ are less than the usual maximum error at about ± 2 mb, except for the particularly high values of $\overline{e_o - e_{10}}$ that occur locally off the West Australian coast, at about 30°S, in November and especially in May. Figures 2a and 4a indicate that the high values are caused by an extension of warm water down the West Australian Coast.

10. In most areas $\overline{\theta_o - \theta_{10}}$ is less than the usual maximum error of about ± 2°C. High values at $\overline{\theta_o - \theta_{10}}$, over + 4°C occur locally along the West Australian coast near 30°S in May and in August. Figures 2a and 2c, 3a and 3c indicate that the high values are caused by extension

of warm water down the West Australian coast, without a compensating increase in air temperature above this warm water.

CONCLUSIONS

11. a. The major source of error in the $\overline{e_o - e_{10}}$ and $\overline{\theta_o - \theta_{10}}$ maps comes from the errors in the maps of the relevant variables given in the World Ocean Atlas (1976).

b. $\overline{e_o - e_{10}}$ decreases toward the south, south of 30°S, in all four months.

c. In most areas, the calculated $\theta_o - \theta_{10}$ is less than the estimated usual maximum error.

d. Locally high values of $\overline{e_o - e_{10}}$ and $\overline{\theta_o - \theta_{10}}$ occur along the West Australian coast near 30°S, in some months.

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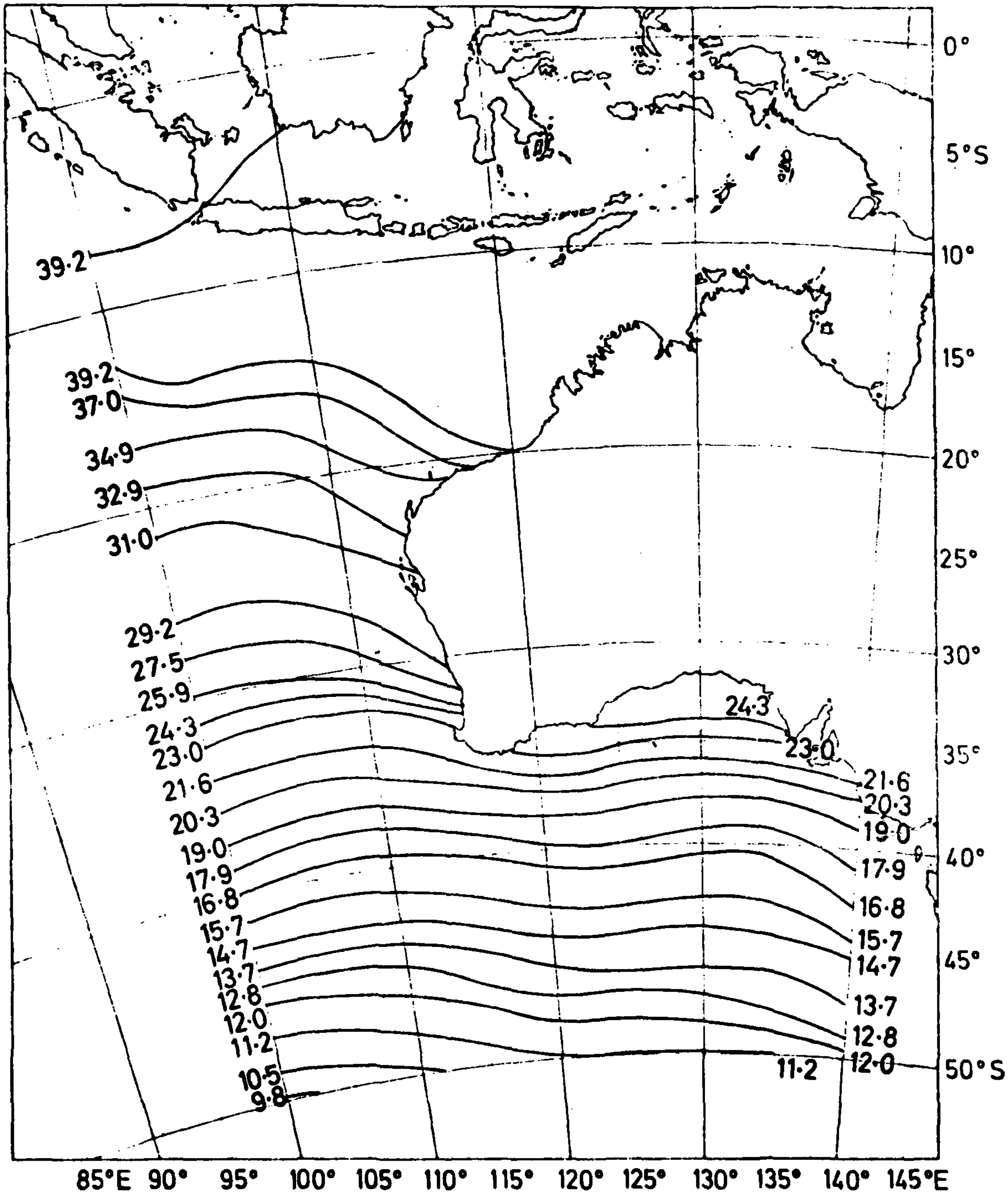

Fig. 1(a) Mean February e_{sat} given in the Pacific Atlas.

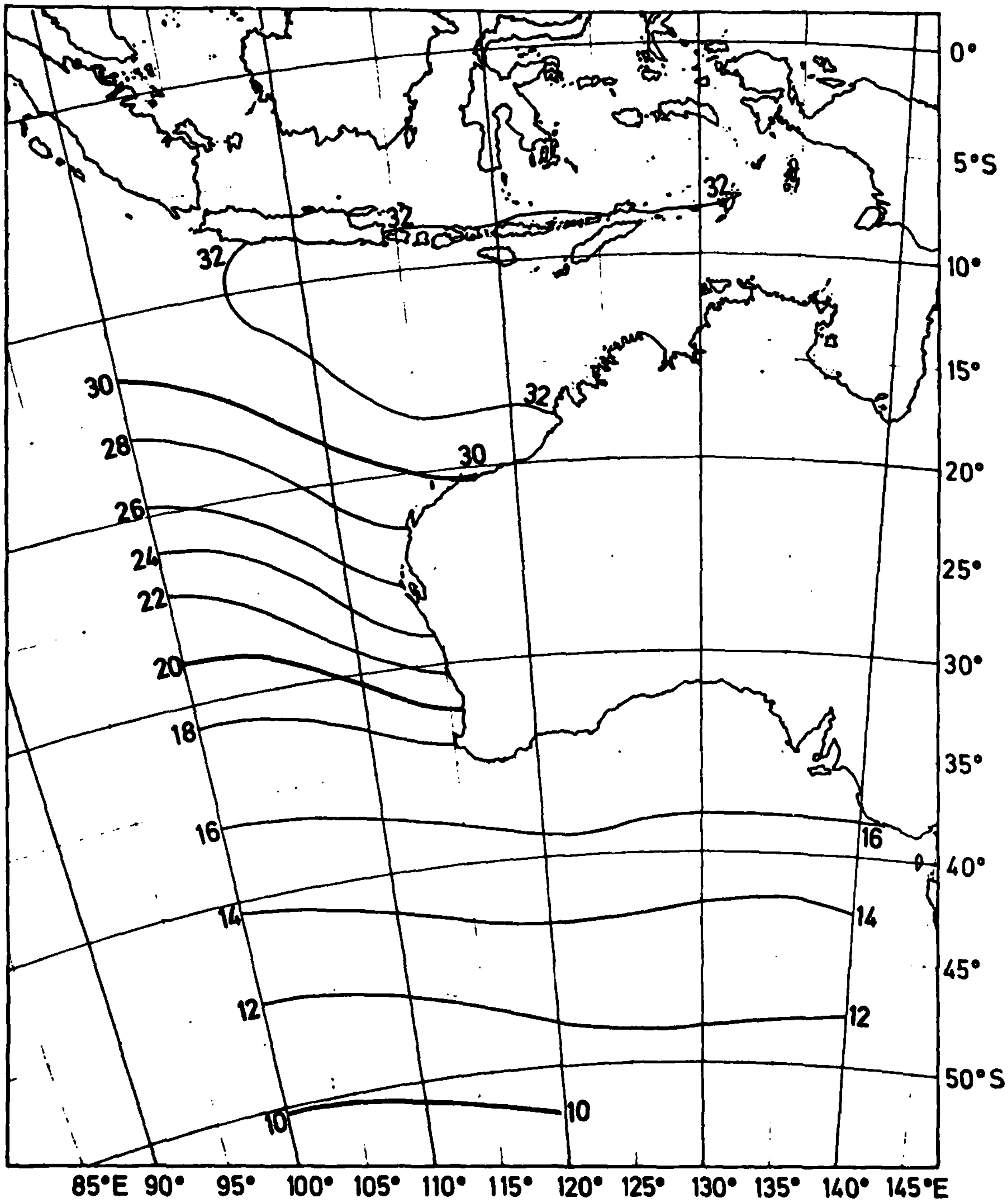

Fig. 1(b) February, $\overline{e_{10}}$ in mb.

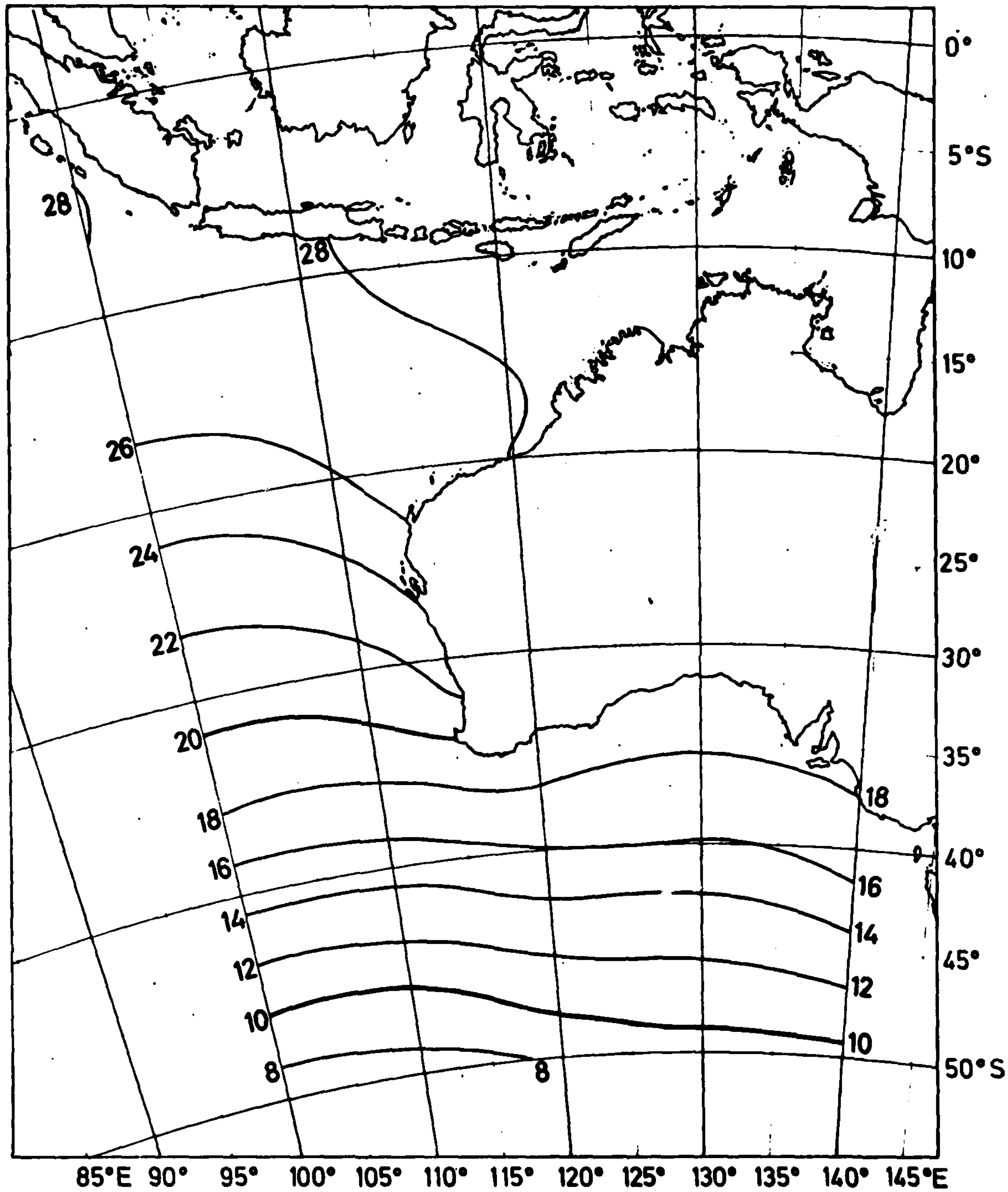

Fig. 1(c) February, $\bar{\Theta}_{10}$ in °C.

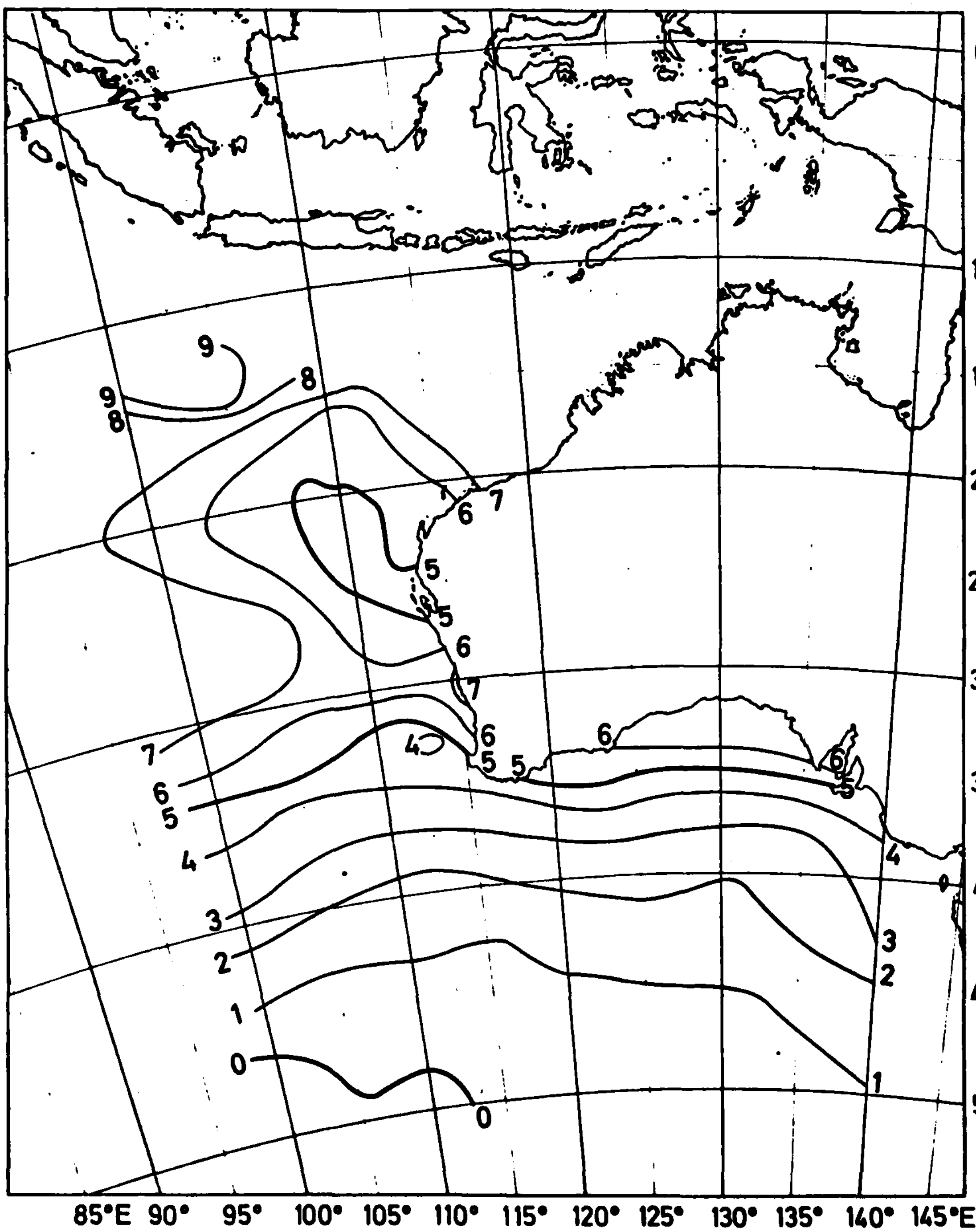

Fig. 1(d) February, $\overline{e_0 - e_{10}}$ in mb.

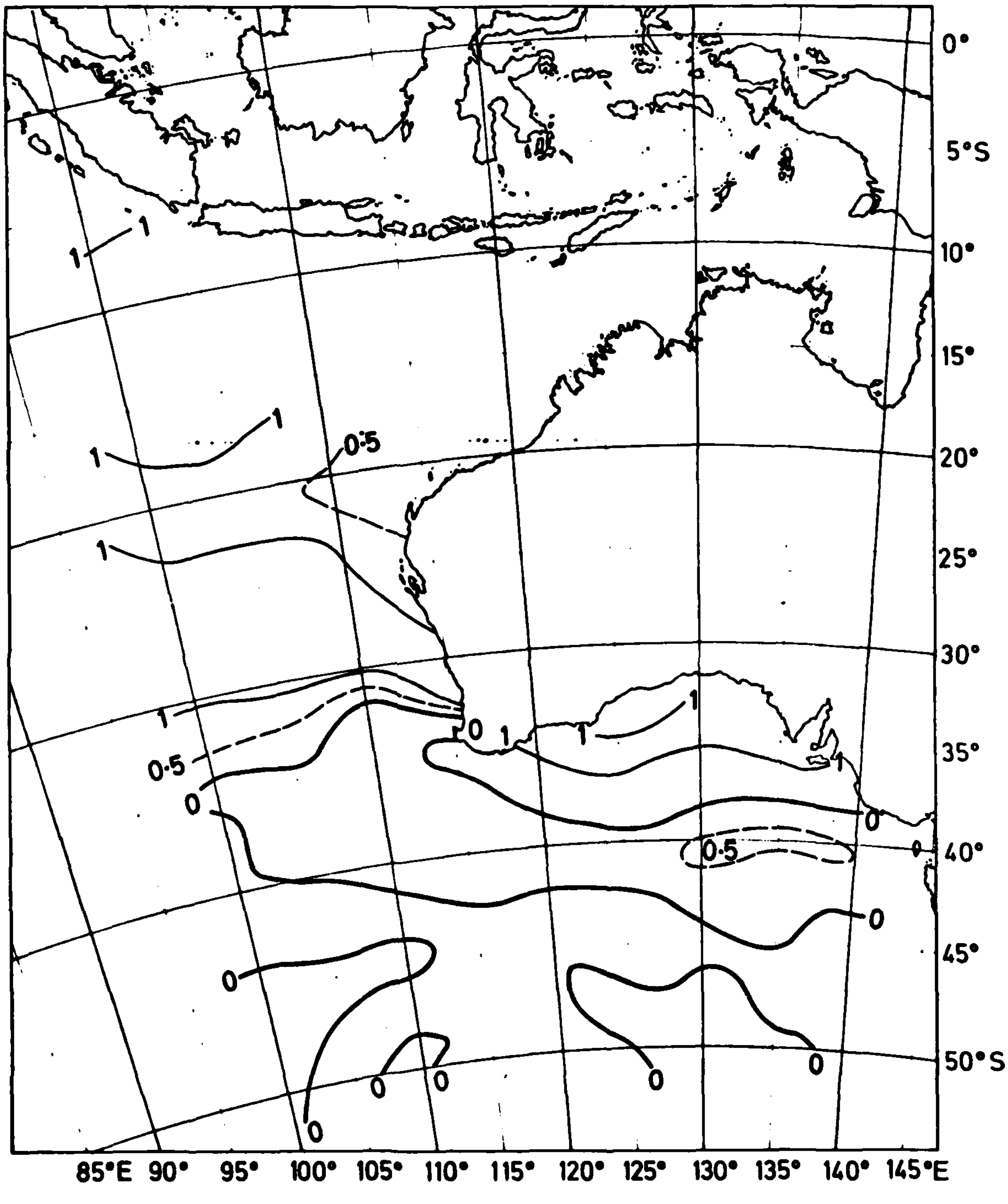

Fig. 1(e) February, $\overline{\Theta_0 - \Theta_{10}}$ in °C.

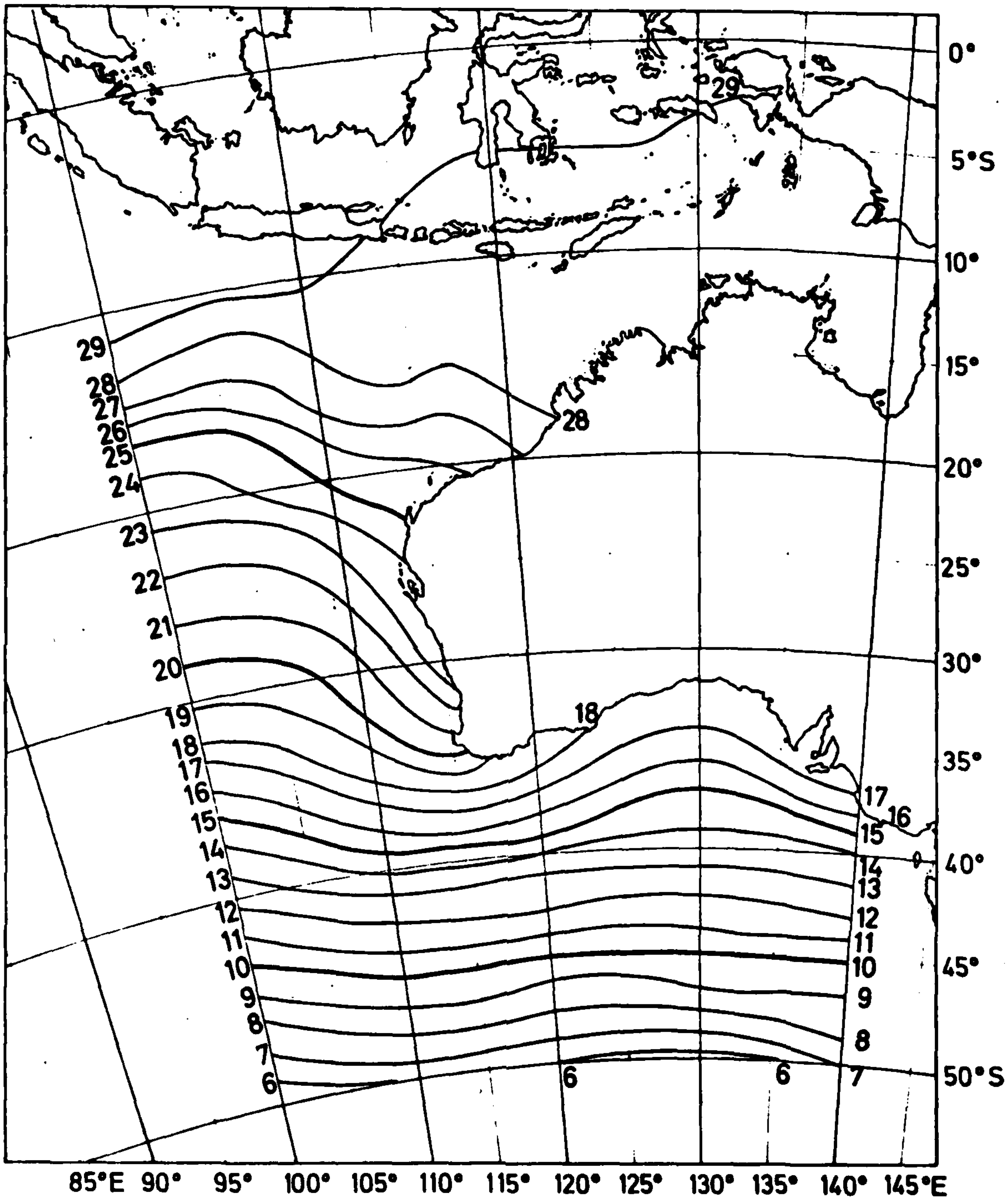

Fig. 2(a) Mean May SST in °C.

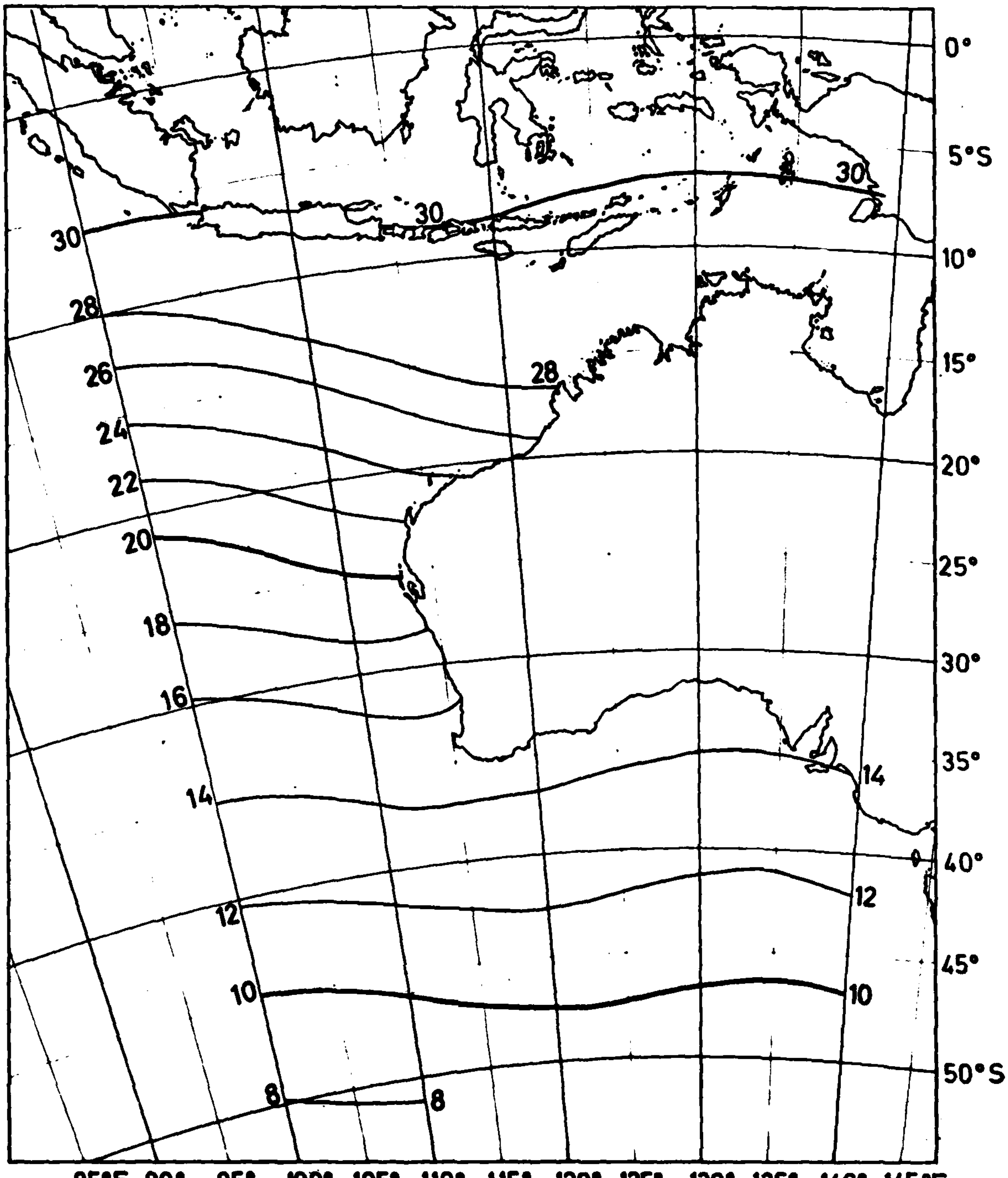

Fig. 2(b) May, $\overline{e_{10}}$ in mb.

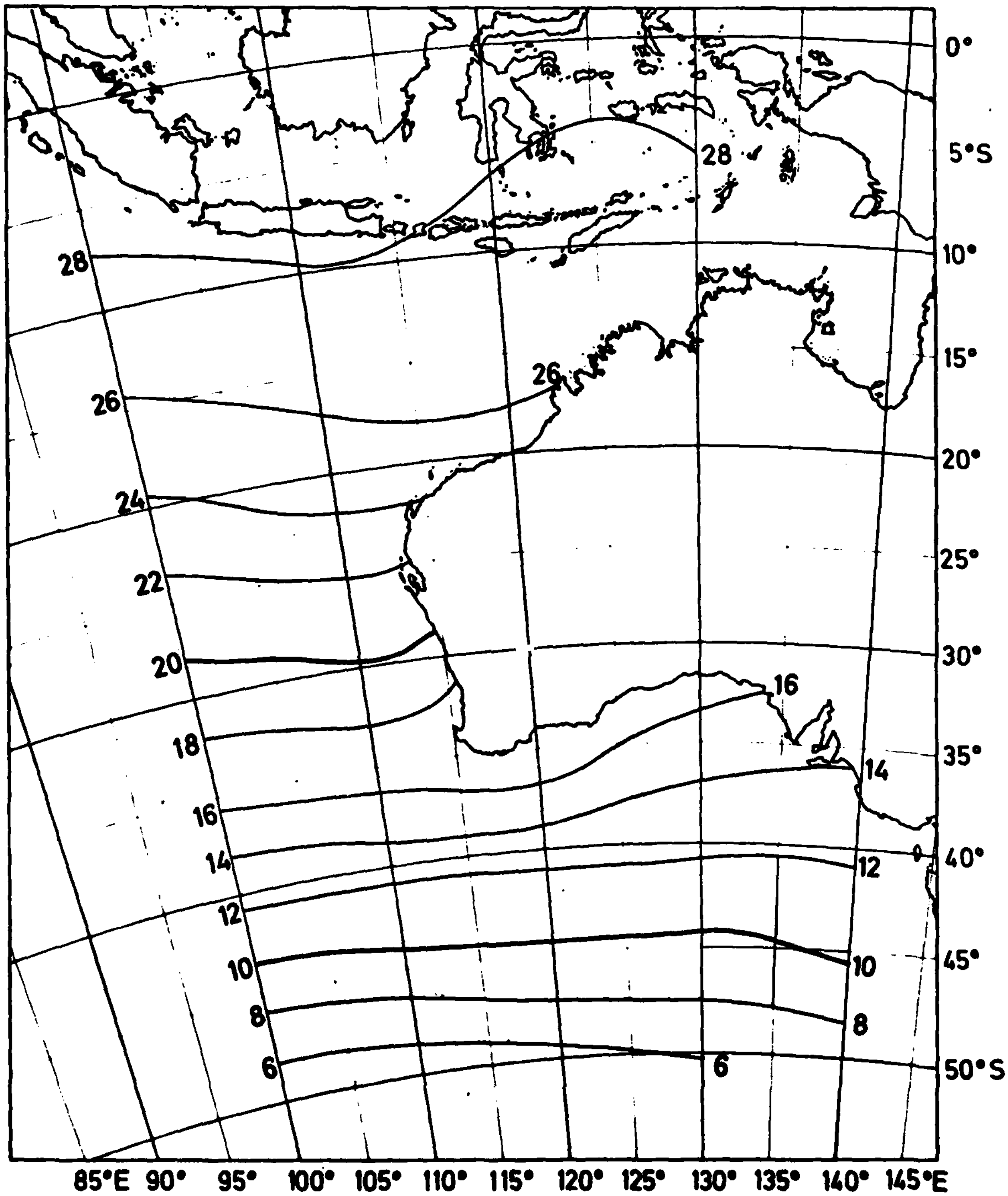

Fig. 2(c) May, $\overline{\Theta_{10}}$ in °C.

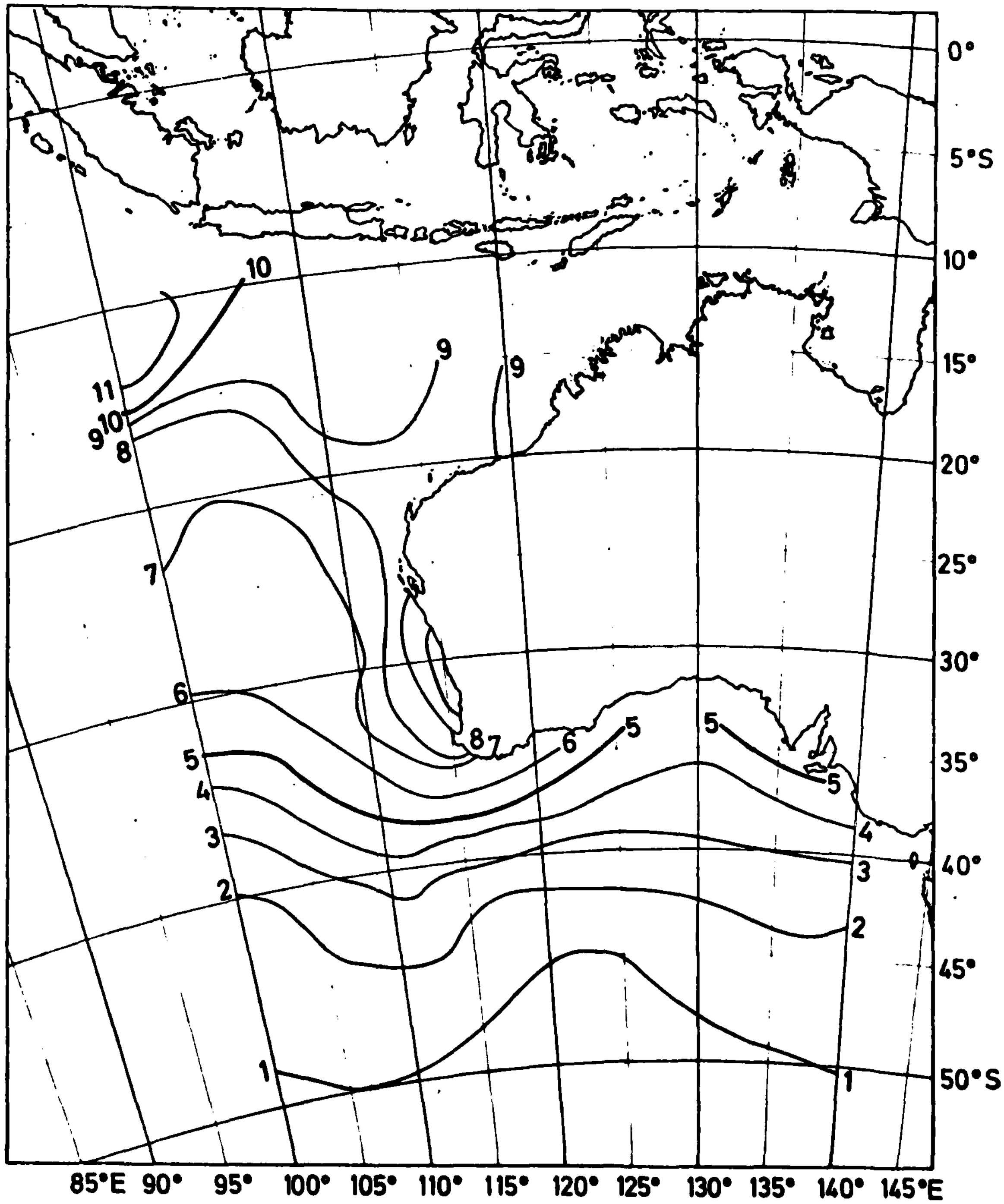

Fig. 2(d) May, $\overline{e_0 - e_{10}}$ in mb.

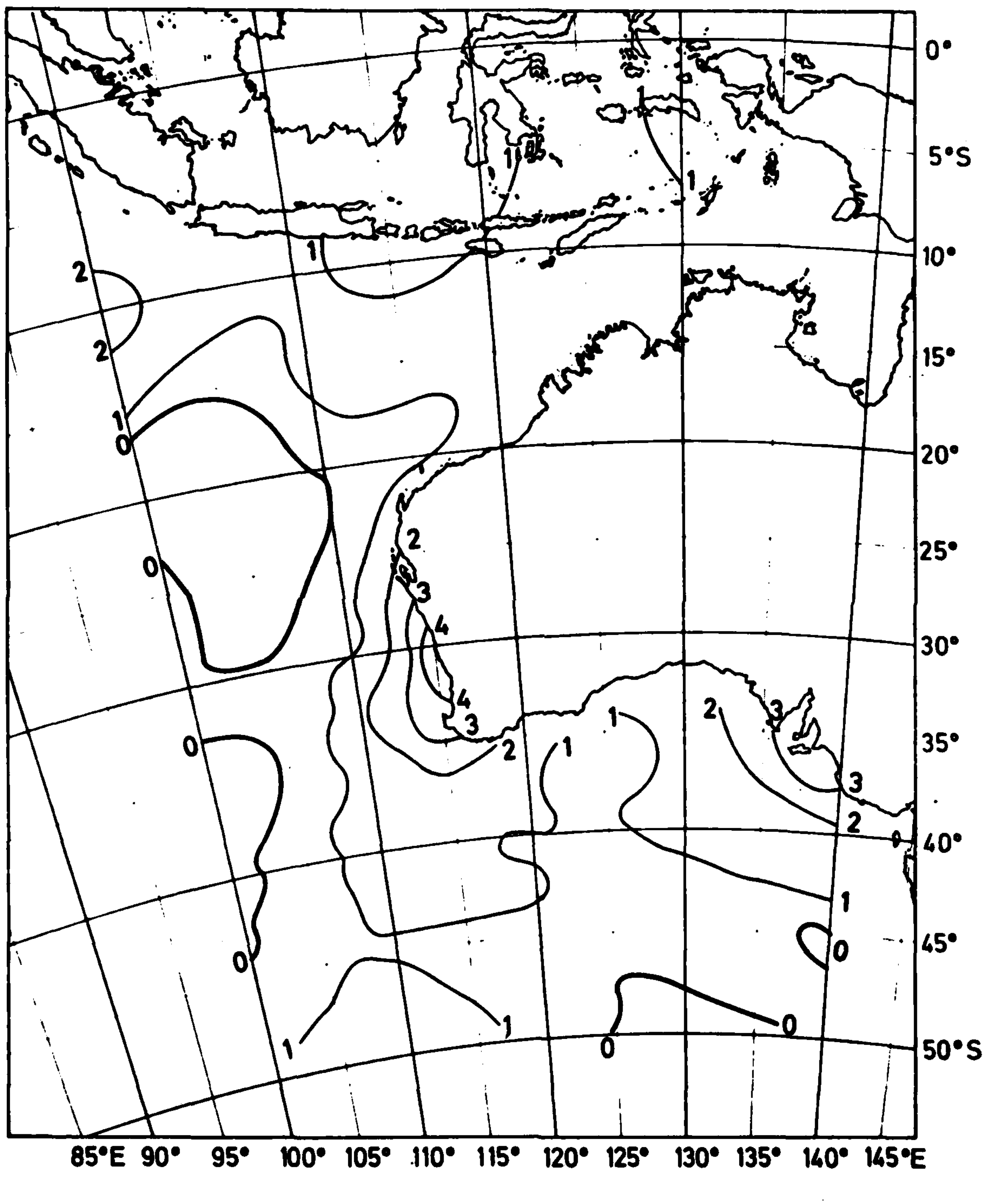

Fig. 2 (e) May, $\overline{\Theta_0 - \Theta_{10}}$ in °C.

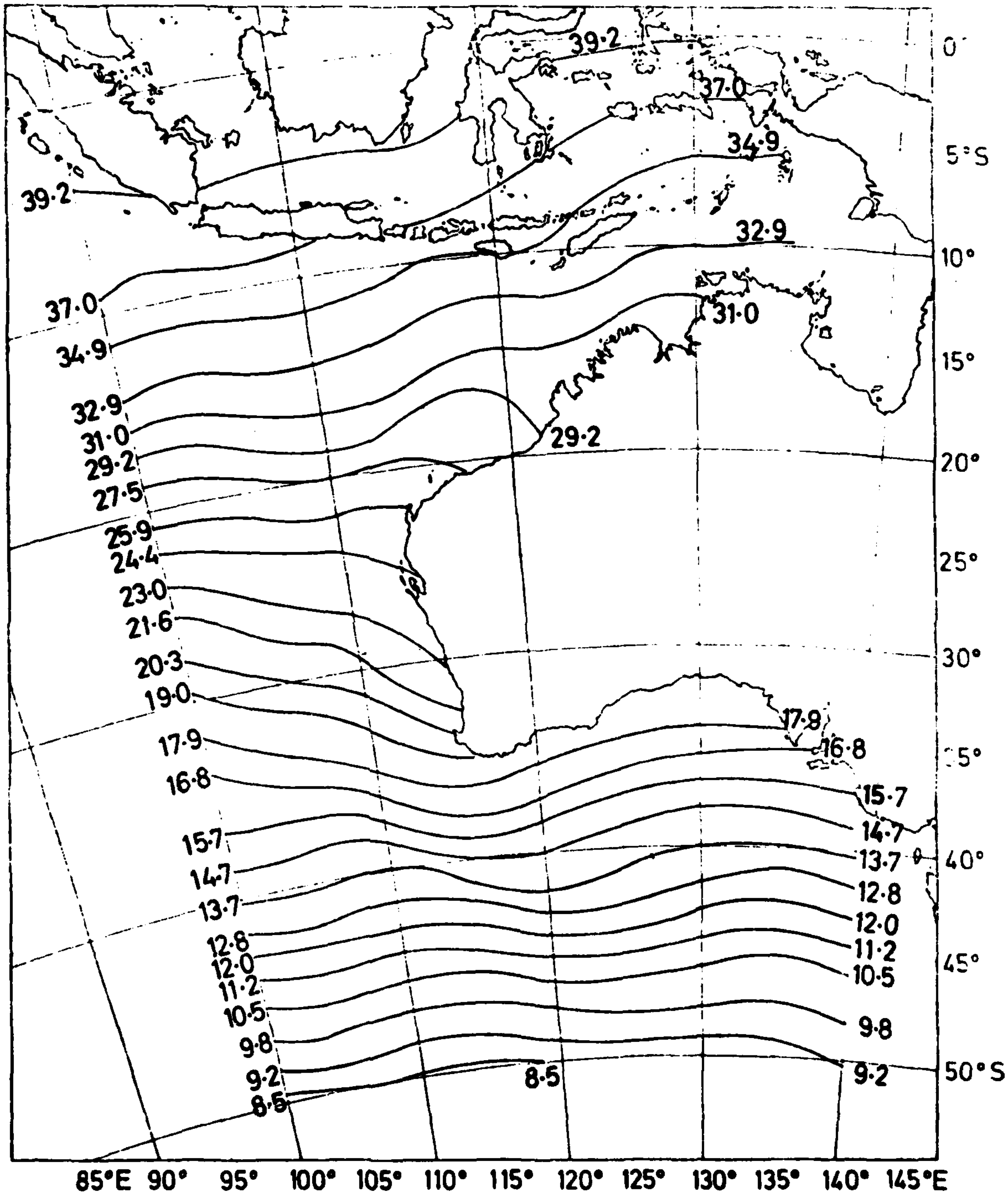

Fig. 3 (a) Mean August e_{sat} given in the Pacific Atlas.

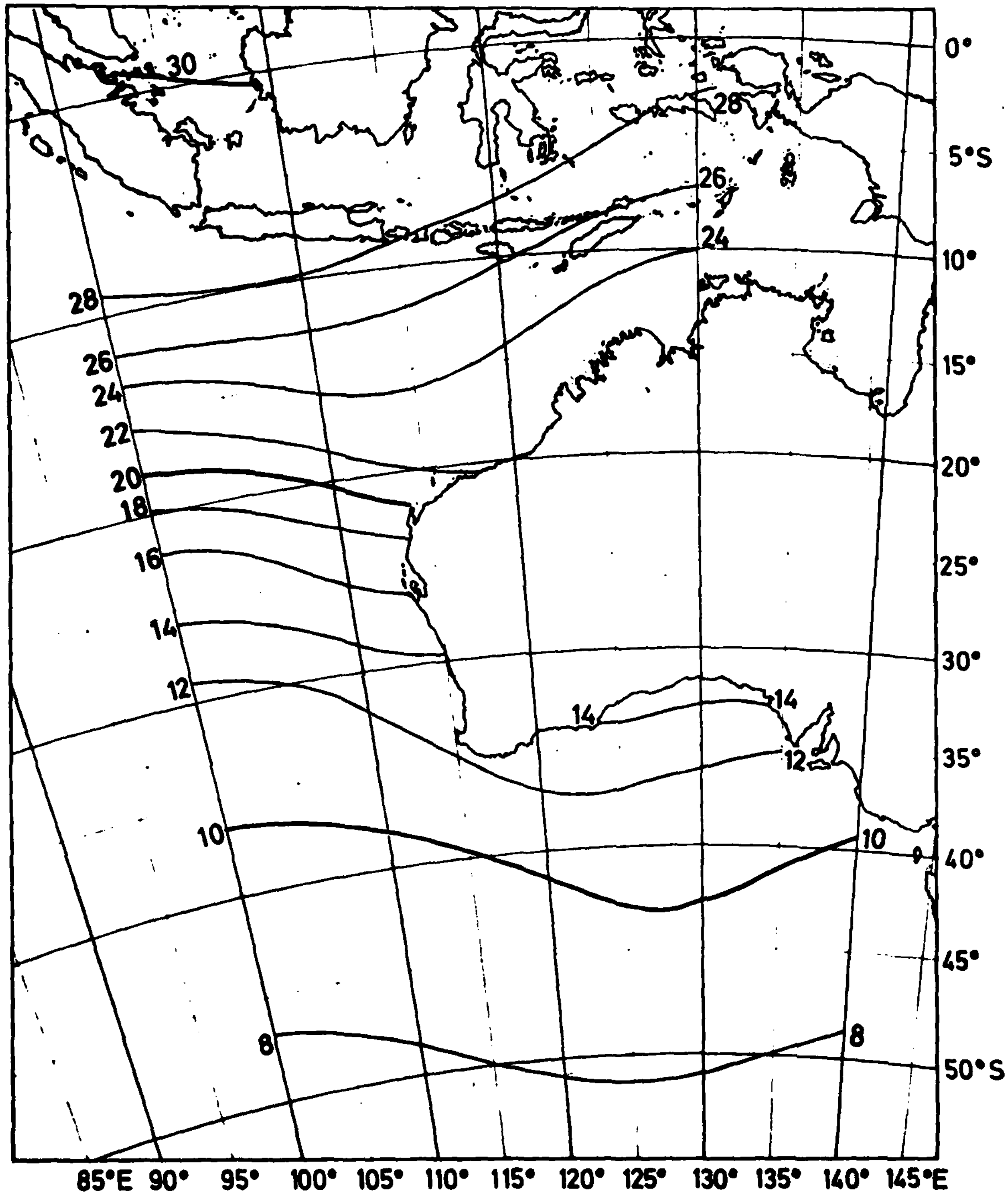

Fig. 3(b) August, $\overline{e_{10}}$ in mb.

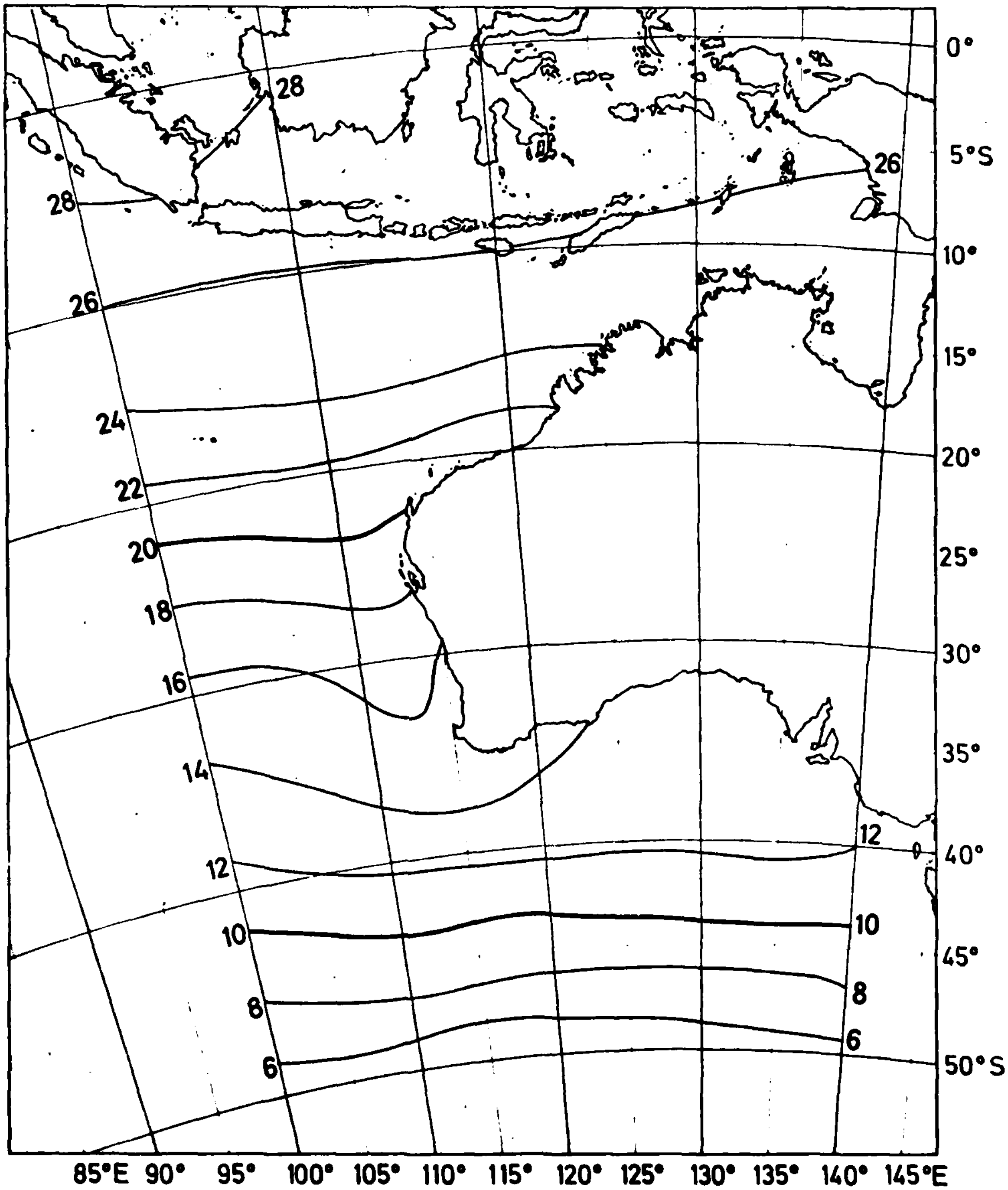

Fig. 3 (c) August, $\overline{\Theta_{10}}$ in °C.

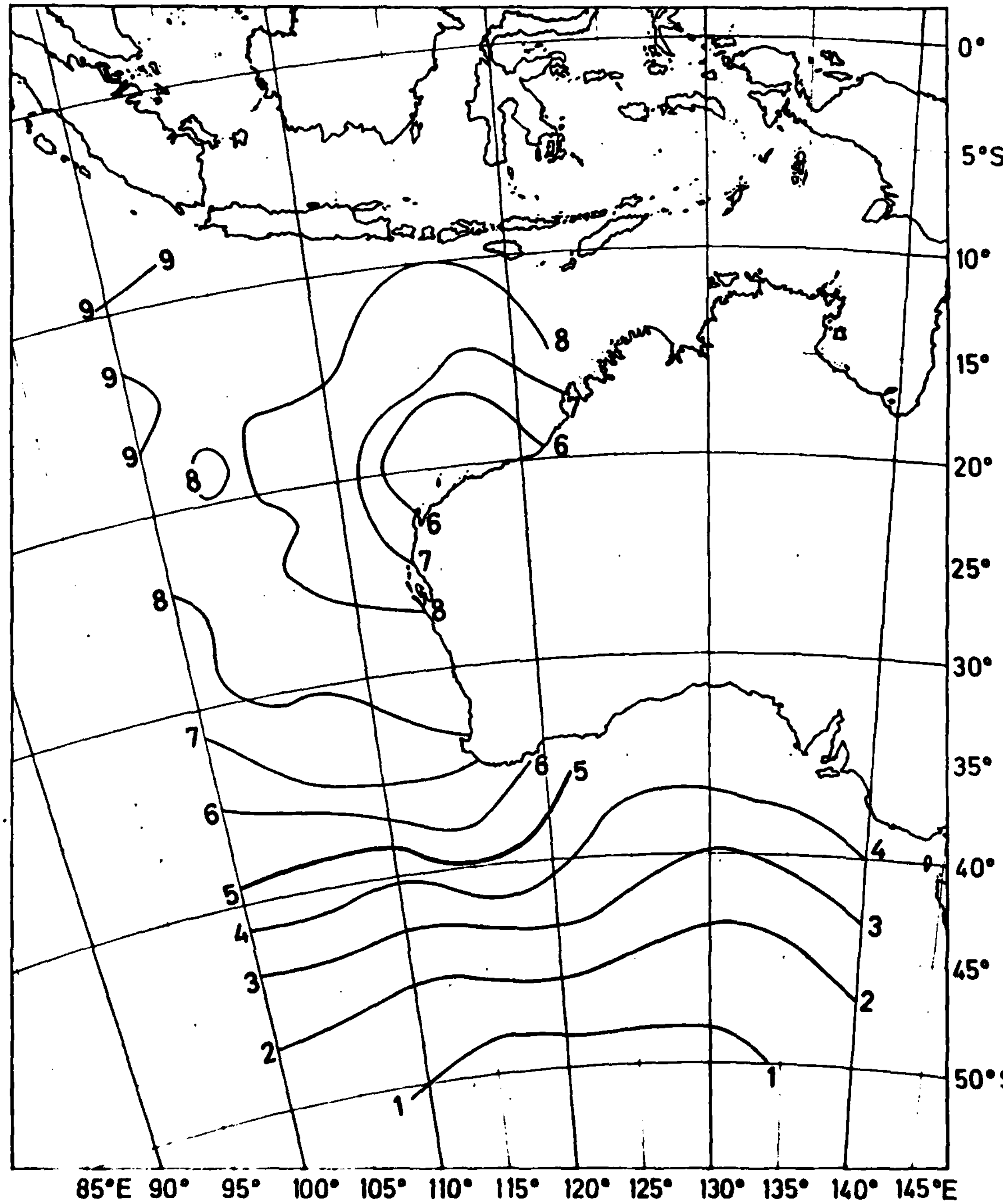

Fig. 3 (d) August, $\overline{e_0 - e_{10}}$ in mb.

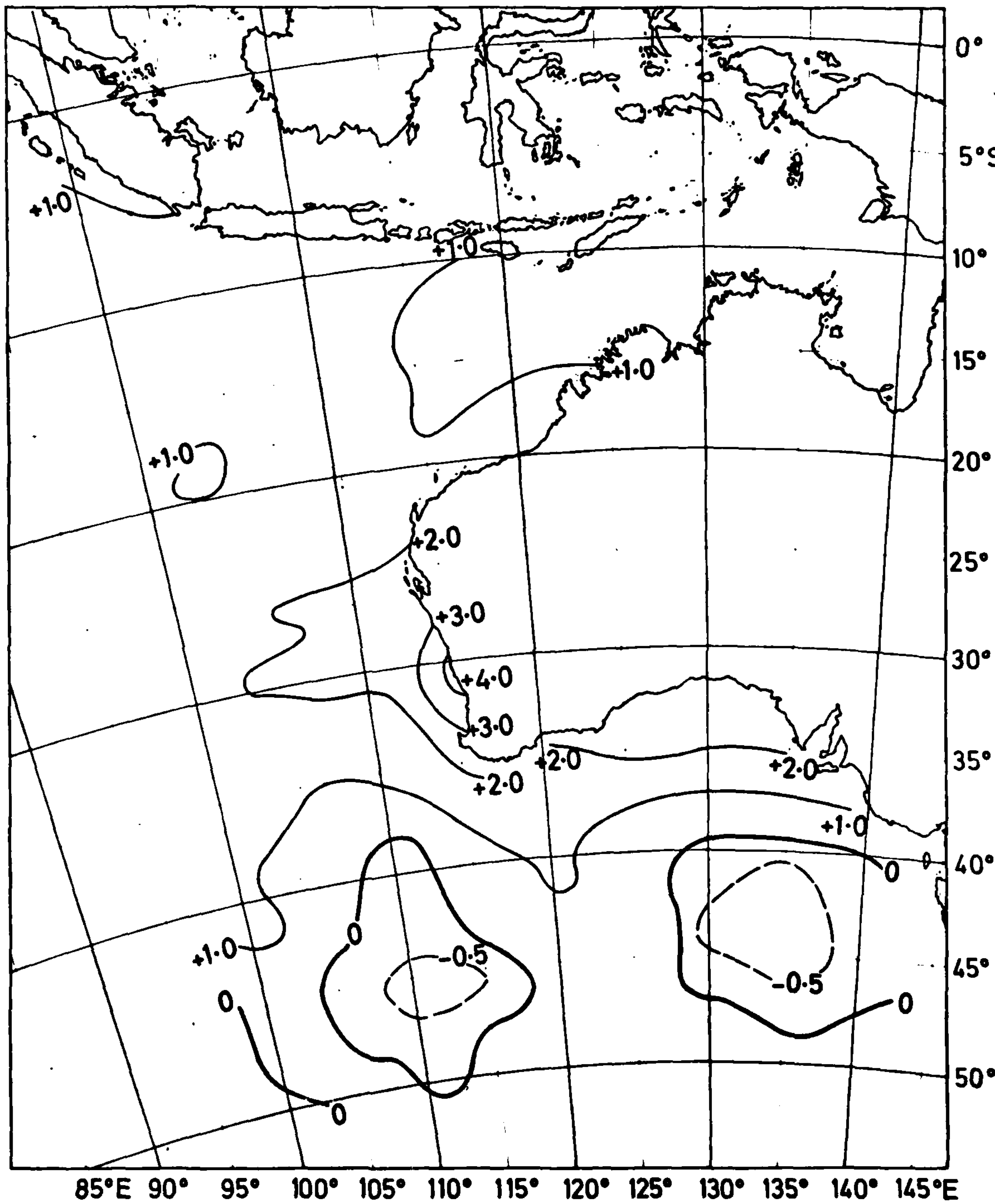

Fig. 3 (e) August, $\overline{\theta_0 - \theta_{10}}$ in °C.

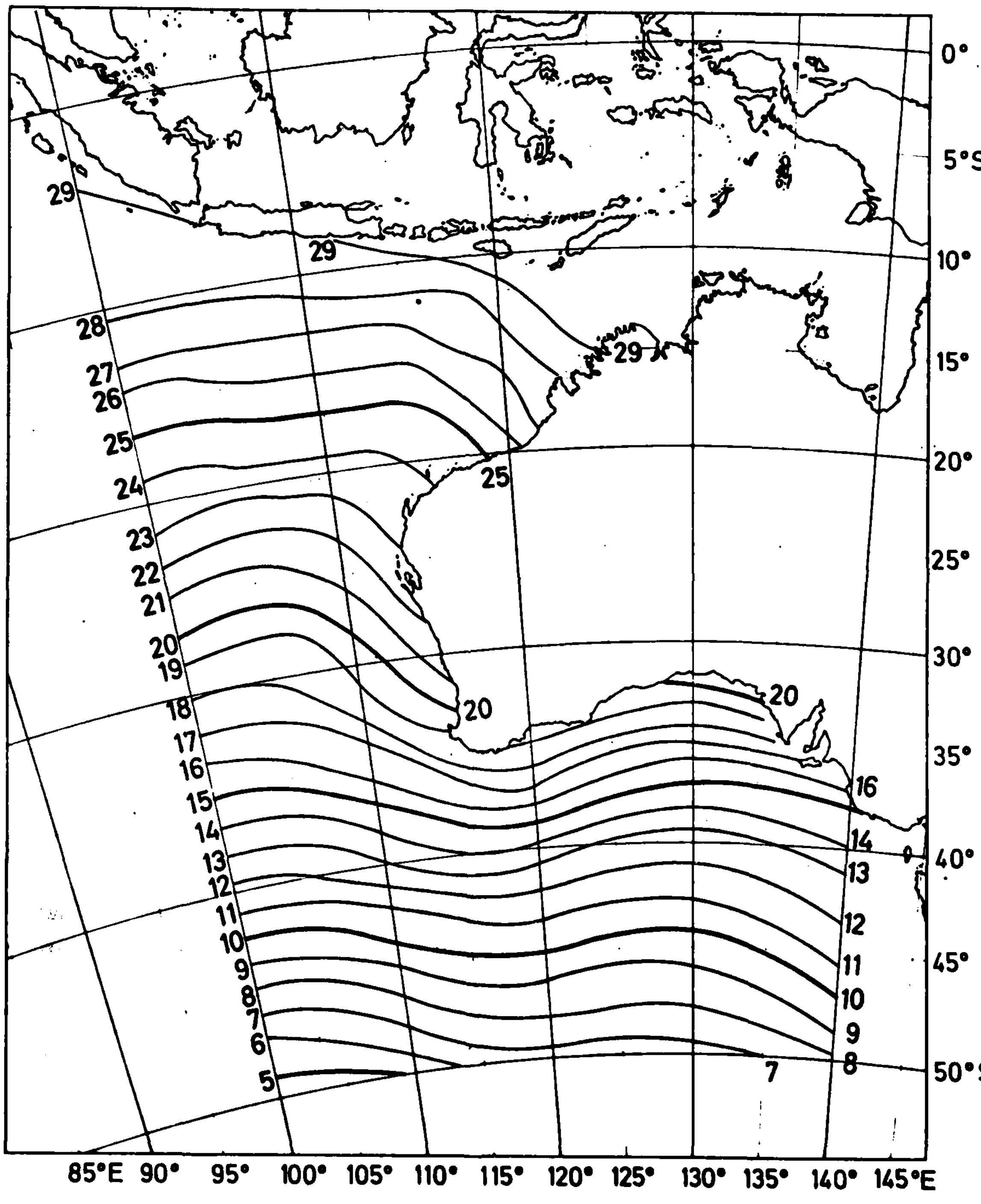

Fig. 4(a) Mean November SST in °C.

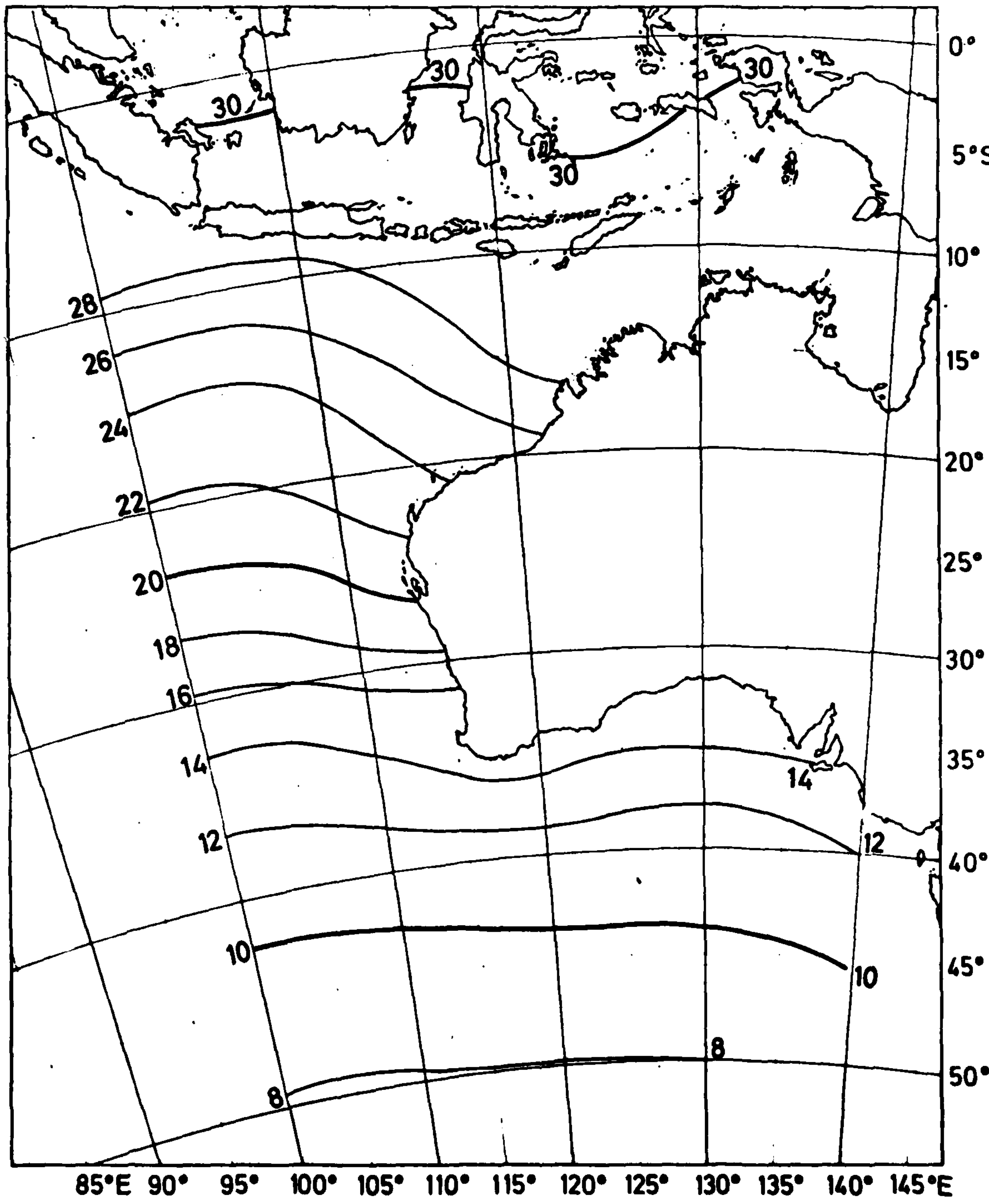

Fig. 4 (b) November e_{10} in mb.

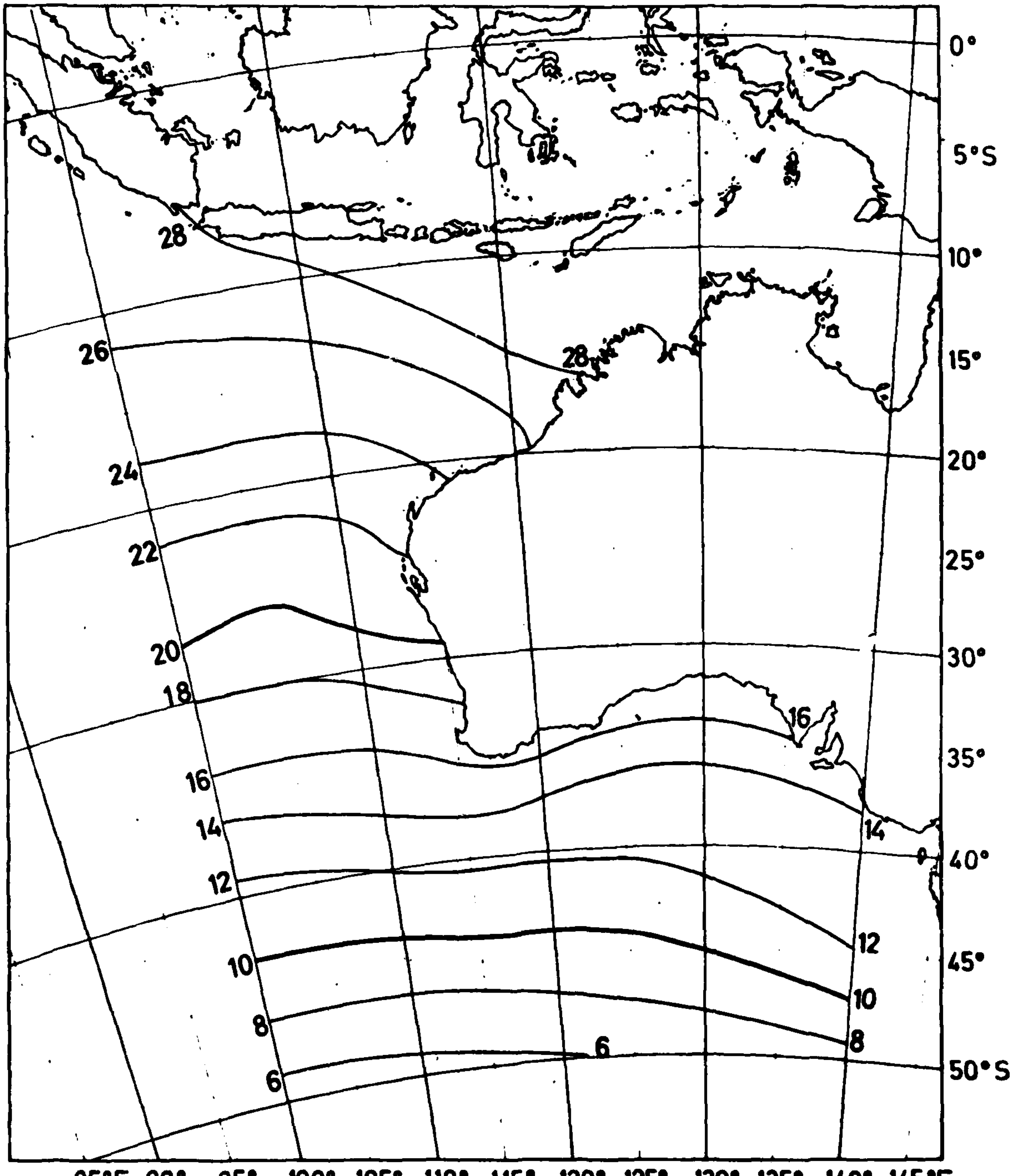

Fig. 4 (c) November $\overline{\theta_{10}}$ in °C.

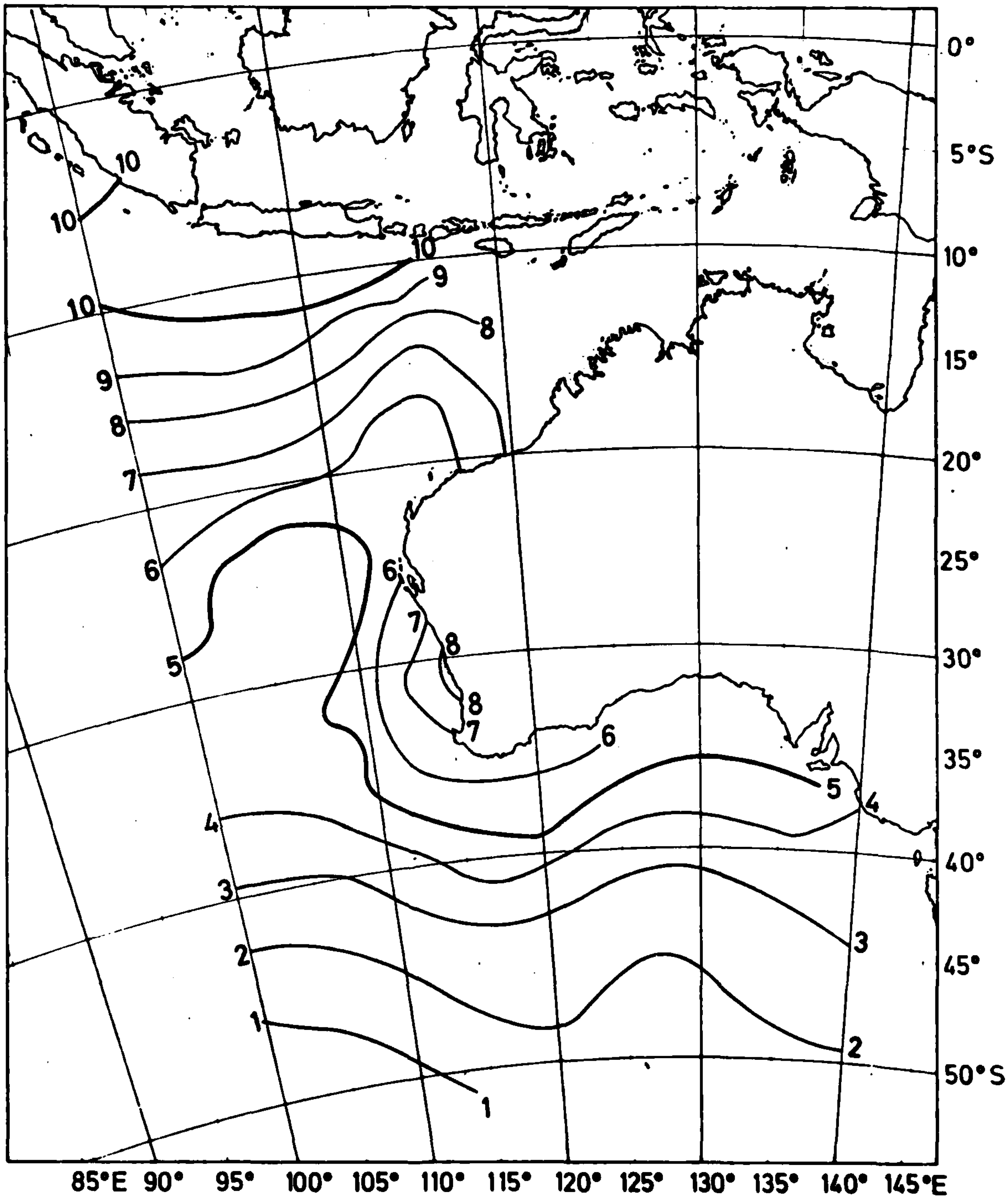

Fig. 4(d) November $\overline{e_0 - e_{10}}$ in mb.

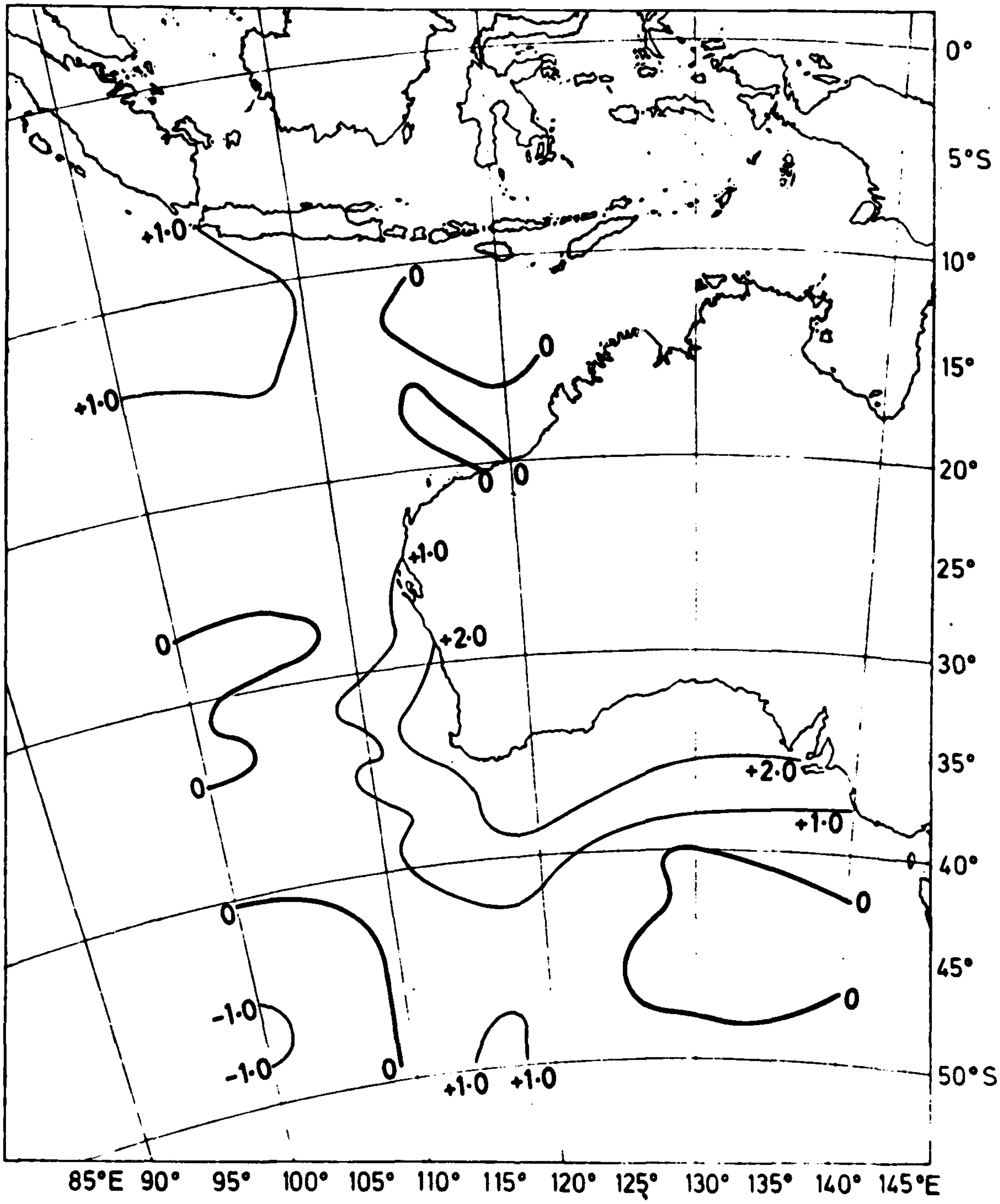

Fig. 4(e) November $\overline{\theta_0 - \theta_{10}}$ in °C.